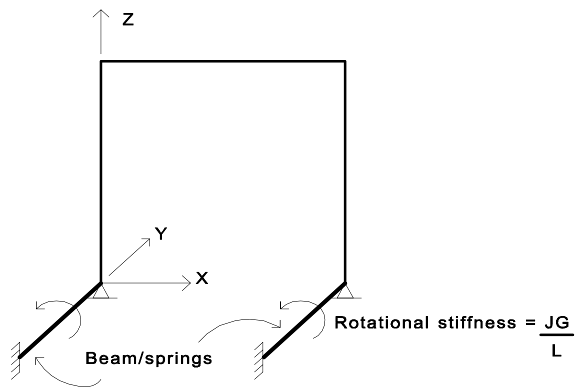
Modeling - Hinges

Objectives:

1) Model hinges in a structure (Moment releases)
2) Model a torsional spring with a beam element

In a similar fashion, rotational springs can be modeled using the torsional stiffness of a beam element. This assumes that the program can handle 3-D structures since the beam must be placed perpendicular to the structure. The figure below shows an example of torsional springs provided by beam elements.

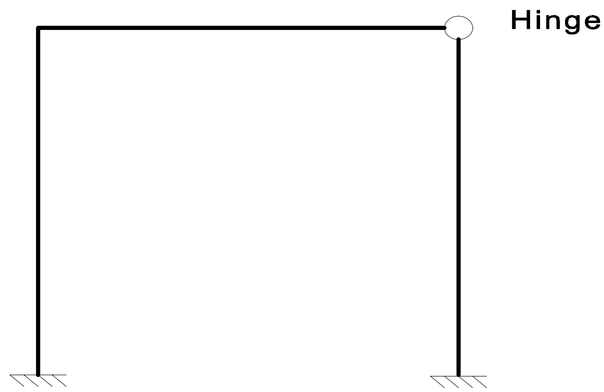


Beam torsion acting as rotational springs

Again, when choosing the length and rotational stiffness (torsional moment of inertia), the values need to be chosen so that the final rotational stiffness has the value of the desired spring. Recall the torsional stiffness for a beam is $\frac{JG}{L}$.

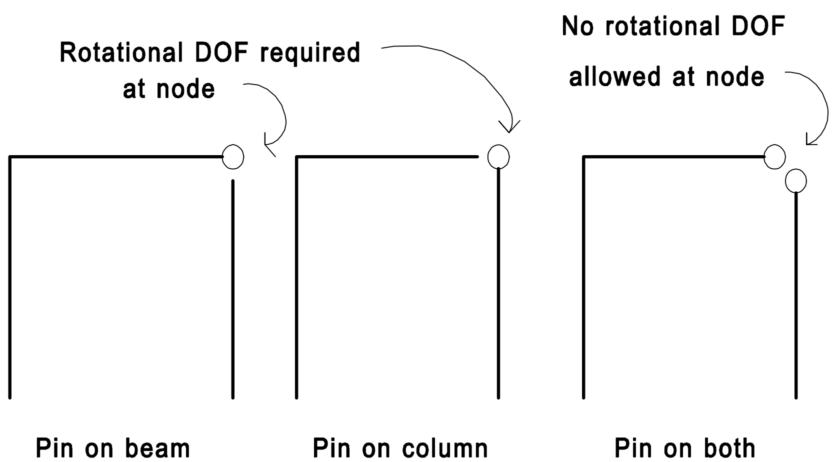
Hinges in structures (moment releases)

The torsional property of a beam can also be used to form hinges within a structure. Many programs allow beams to have pins at the ends of beams. However, a large number do not. A beam element can be used to model this condition.



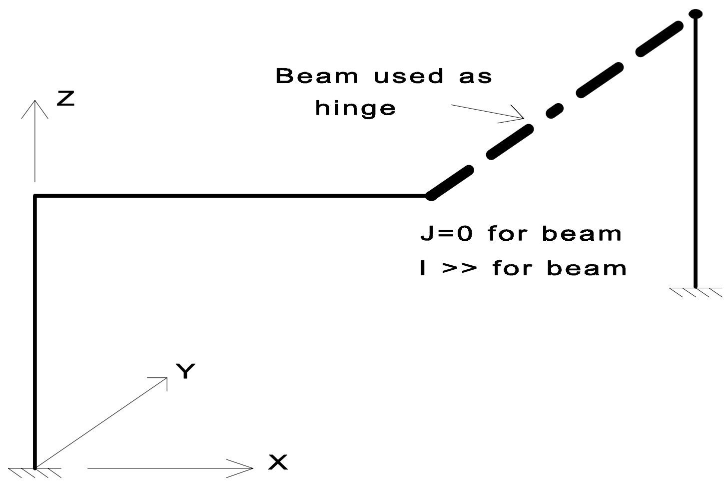
Example Frame with a Hinge

If the program has pinned ended beams (moment releases for members), then all that would be required is to place a pin at the right end of the beam. Note that a hinge must not be additionally placed at the end of the right hand column if the rotational DOF of the corner is released. This is because one of the members (beam or column) must add stiffness to the node. If both are pinned, then it is like connecting truss bars to a node where no rotational stiffness exists. So in reality, the pin can exist at either the top of the column or the right end of the beam and get identical results. If pins exist at both, then the rotation at the node must be fixed.



Possible pin locations on member ends
to create a hinge.

If the program does not offer pinned ended beams, then an alternative approach is to use a beam with zero torsional stiffness. Again, this creates a 3-D model, but it is exact. The following structure shown below could be used.

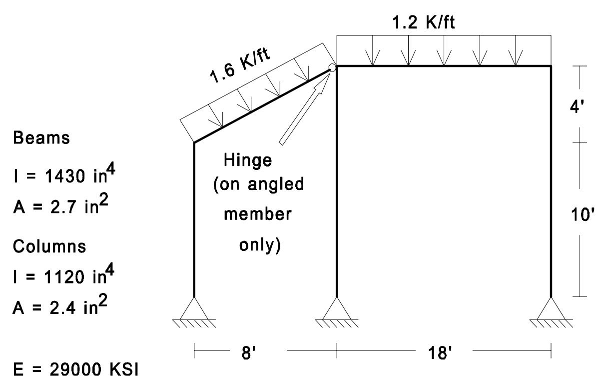


Hinge modeled by beam with J=0

Note that in order to maintain compatibility of the other displacements, large values for area and the two moments of inertia must be used. The torsional moment of inertia must be zero. Again, when choosing values for A and I to constrain the lateral and vertical DOF to be the same, you must use relative values. The rule of thumb is to choose values 1000 times the connected stiffness values. In this case, just use 1000 times the moments of inertia of the beam and/or column.

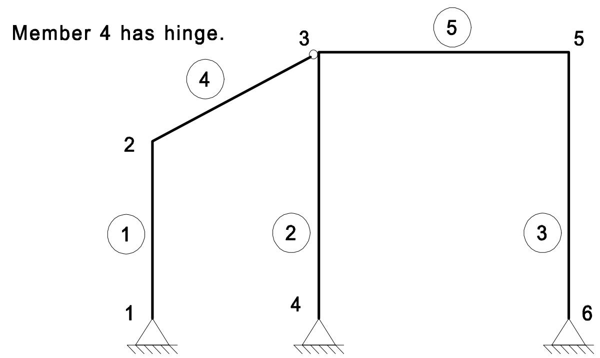
Hinged Member Example

The following single bay structure is having a frame with a slanted roof attached. The attachment connection is to be considered as a hinge. Analyze the complete structure to find the moments in the original beam so that they can be later checked for adequacy.



Example Including a Hinge on a Member

In order to create the SSTAN input, we need to number the nodes and elements. The following figure gives the numbering.



Node and Element Numbering

Using the two figures, the following input file was created:

```
Condensed Example - Hinged Member
6,1,1                 : 6 nodes, 1 type (beams), 1 load
:
Coordinates
1 x=0 y=0 z=0
2 y=10*12
3 x=8*12 y=14*12
4 y=0
5 x=26*12 y=14*12
6 y=0
:
Boundary
1,6    DOF= r,r,f,f,f,r    : set all to 2-D
1,4,3  DOF= f,f,f,f,f,r    : Pin supports
6      DOF= f,f,f,f,f,r    : Pin support
:
Beams
5,2
1 a=2.7 i=1430 e=29000     : Beams
2 a=2.4 i=1120             : Columns
C--- Columns
1 1,2,6 m=2
2 4,3,6
3 6,5,1
C--- Beams
4 2,3,1 m=1 l=-1.6/12 p=2  : Slanted, Hinge at J (3) end
5 3,5,4     l=-1.2/12      : K node below, load negative
:
```

Note how the hinge is assigned to member number 4. The J end (node 3) of the slanted member is hinged. Also notice that no concentrated loads are used. After running SSTAN, the two beam members output looks like:

```
      ---------------------- FRAME MEMBER RESULTS ----------------
  MEM LOAD NODE           1-2 PLANE              1-3 PLANE      AXIAL FORCE
    #    #    #      MOMENT       SHEAR      MOMENT       SHEAR
    4    1    2  .00000E+00  .00000E+00 -.27956E+03 -.45508E+01 -.32921E+00
```

```
             3  .00000E+00  .00000E+00  .00000E+00 -.97600E+01  .32921E+00
                                                  AXIAL TORQUE =   .00000E+00
 ** MAXIMUM MIDSPAN MOMENT =   .357E+03 AT DISTANCE    34.13 FROM NODE     2
    5    1    3  .00000E+00  .00000E+00 -.11441E+03 -.76342E+01  .33894E+01
             5  .00000E+00  .00000E+00 -.56941E+03 -.13966E+02 -.33894E+01
                                                  AXIAL TORQUE =   .00000E+00
 ** MAXIMUM MIDSPAN MOMENT =   .406E+03 AT DISTANCE    76.34 FROM NODE     3
```

See how the moment at node 3 on member 4 has a value of zero. Also notice that both member have a positive moment in the span. In the case of member 4, the moment is larger than the end moment.